Containerless Processing Technology

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MSFC ESL and TEMPUS MSL Teams

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  - Dr. Jan Rogers, MSFC
  - Dr. Konrad Samwer, University of Augsberg
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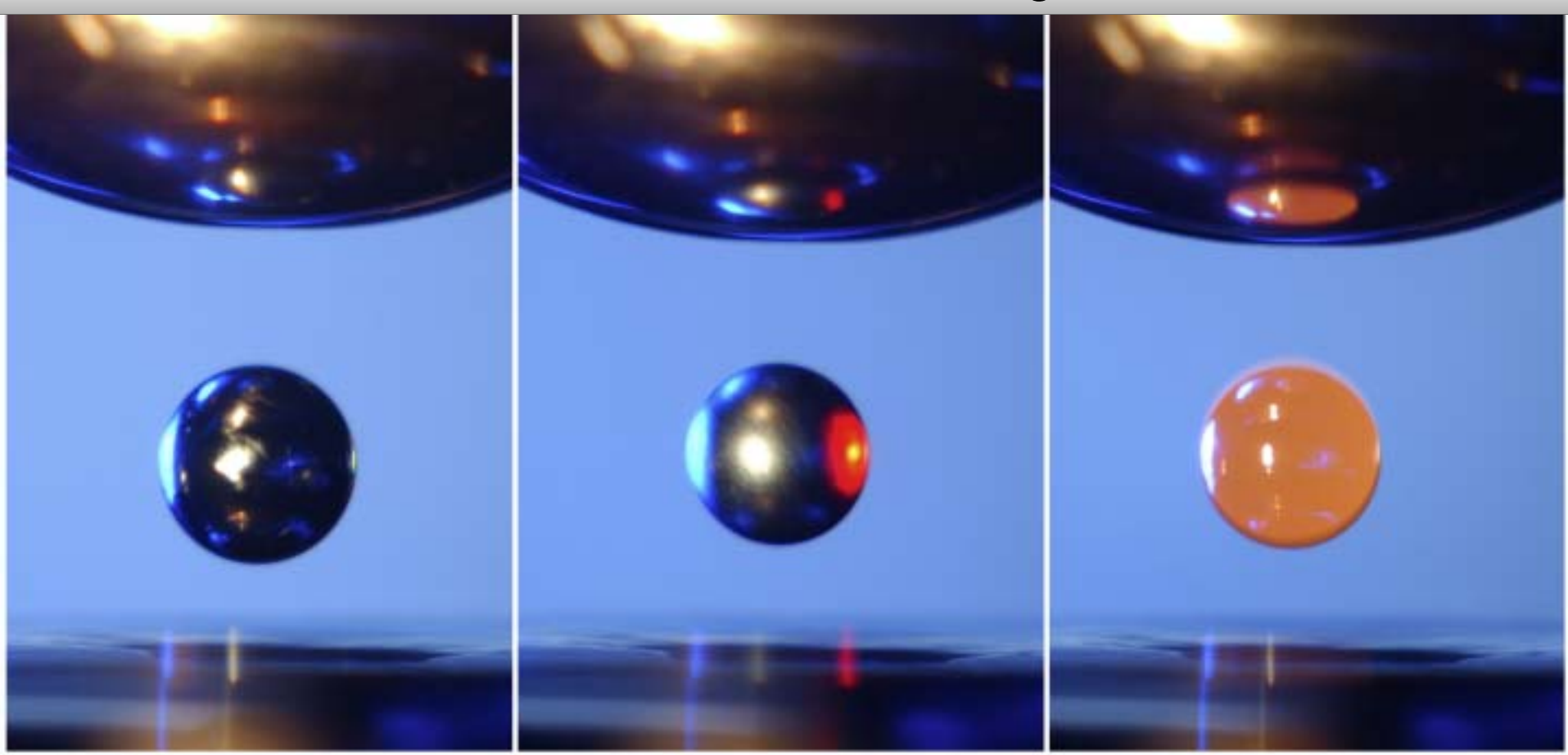
Containerless Processing



- Levitation
- Force positions and manipulates sample
- No contact with container during processing

Current Status

- Ground based systems for several methods including:
  - Electrostatic
  - Electromagnetic
  - Acoustic
  - Aerodynamic
  - Other

Reduced Gravity

- Benefits: greatly reduced positioning forces, larger masses, spherical specimens and reduced phase separation due to buoyancy
- Shuttle examples:
  - Electromagnetic (DARA TEMPUS)
  - Acoustic (NASA DPM)
- Future possibilities include:
  - ISS Electromagnetic (ESA MSL-EML)
  - ISS Electrostatic (NASDA ELF)
  - Free Space processing

Reduced Gravity Technology Considerations

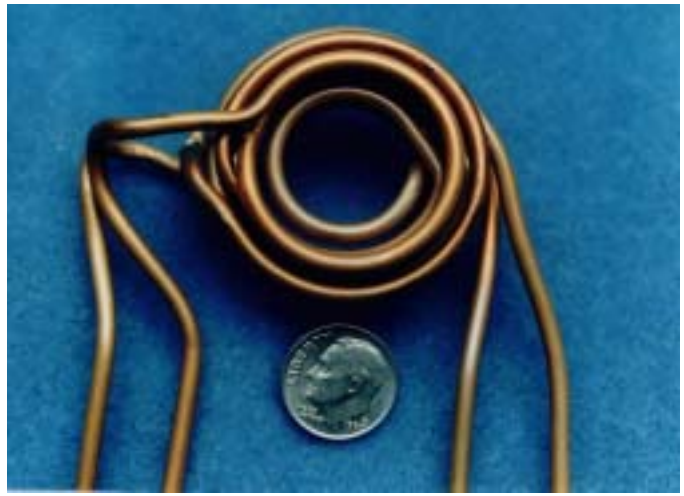
- Environment may require new designs and procedures
- Full implications of reduced gravity operations may not be intuitive
  - Containment of process materials and waste require special consideration
  - Testing of equipment and procedures in appropriate environment is important
- Process models may need to include "2nd order effects" often masked in 1-g
  - Code U program has developed a significant body of literature on these effects for material processing
  - Bibliography in OBPR Research Task Books (http://research.hq.nasa.gov/taskbook.cfm)
- Acceleration environment should be understood

Acceleration Environment

- Spacecraft environment is not zero-g
- Complex acceleration environment (course on ISS offered by PIMS Group at GRC)
- Sources include:
  - Atmospheric drag
  - Displacement from spacecraft center of mass
  - Spacecraft maneuvers
  - Equipment
  - Activities

TEMPUS Flight History

- IML-2
  - Sample stability issue
- MSL-1
  - Shortened mission
  - Reflectors perturbed magnetic field
- MSL-1R
  - Reflight, reflectors removed
  - Highly successful



Sample Processed During “Quiet” Spacelab

- 8 mm diameter sample
- Processed when other Spacelab equipment was turned off
- Sample motion still visible
- Ran a series of tests
- Able to demonstrate effects of reflectors on magnetic field
- This sample cage did not have reflectors
- Reflectors removed for MSL-1R

Sample Processing during 1-10 Hz Disturbances

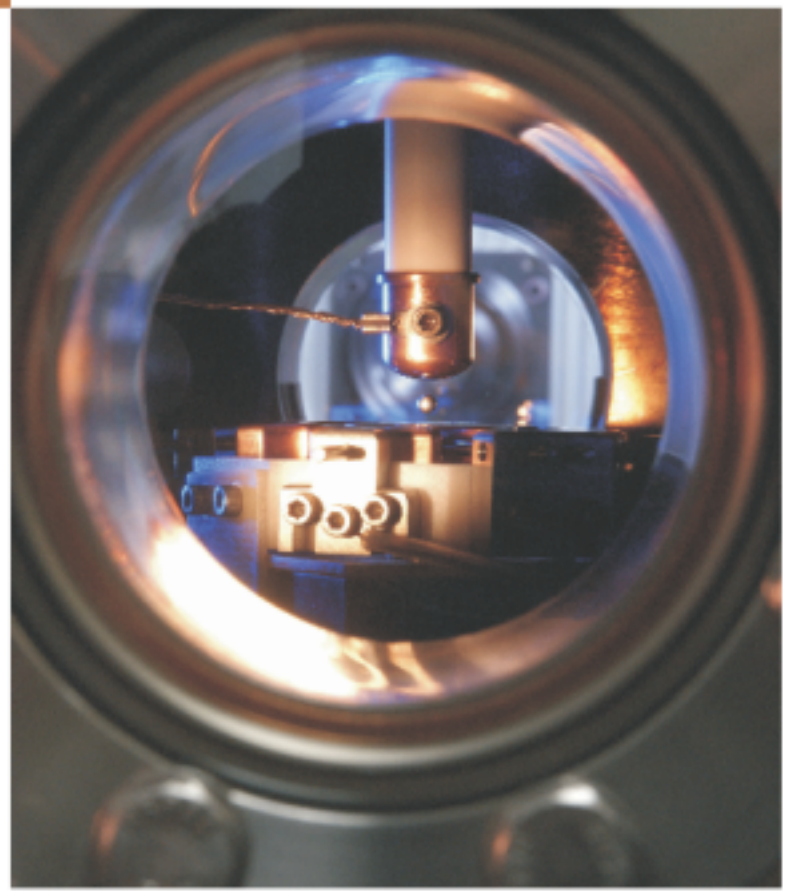
TEMPUS Containerless Processing Summary

- Developed robust equipment and procedures to provide excellent data to all 10 PI teams
- Developed strategy to avoid problems associated with acceleration environment
  - Scheduled operations to avoid processing during 1-10Hz disturbances
  - Monitored environment and worked with accelerometer groups to suspend operations during 1-10Hz disturbances
  - Informed of crew exercise plans
- Crewed flight was essential to success of TEMPUS. Crew members performed a critical In-Flight repair

Alloy Developed by Dr. Bill Johnson using Containerless Techniques

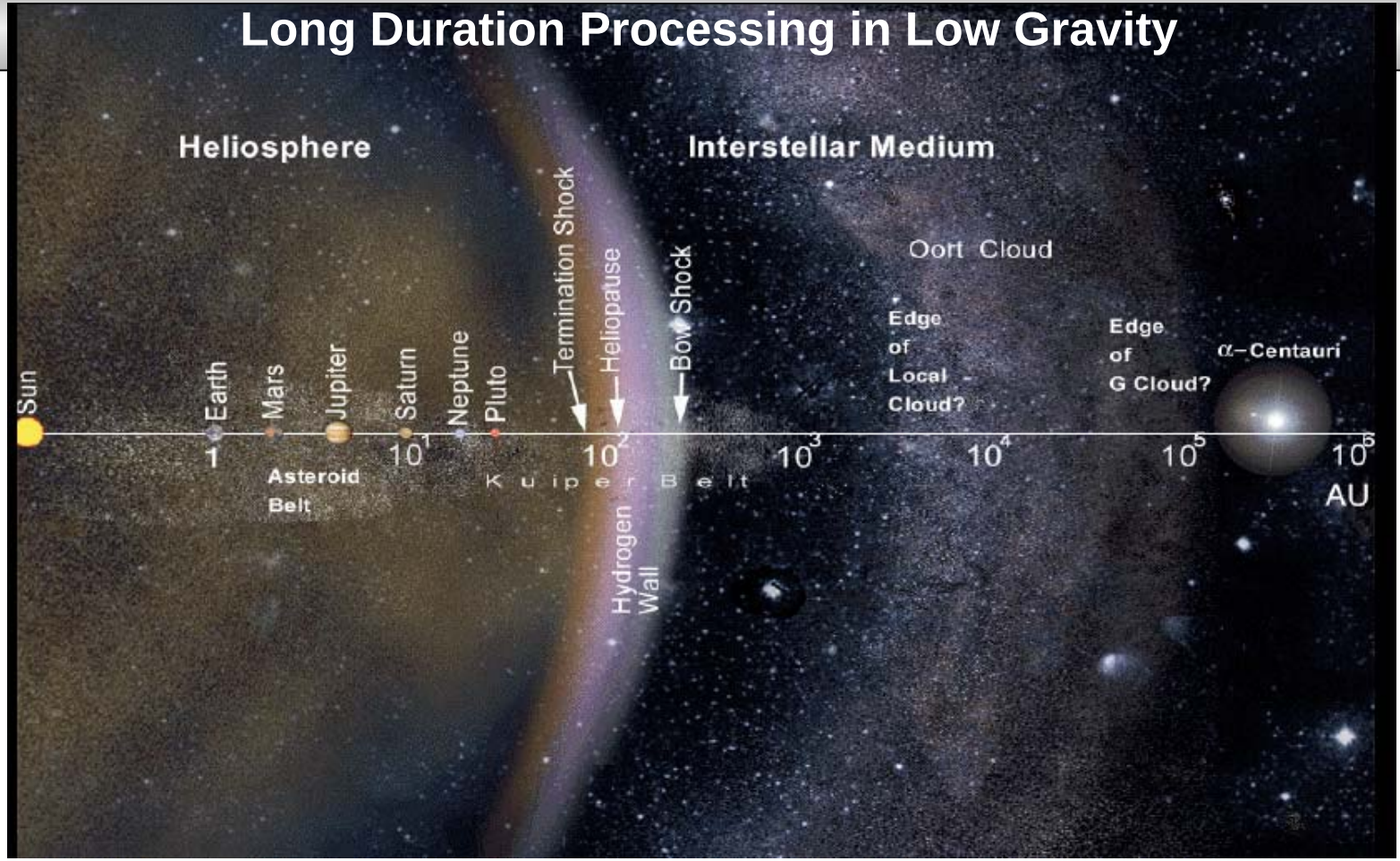
JULY
2003

PHYSICS TODAY



Targeting molten metals

Long Duration Processing in Low Gravity



Uniqueness of Low Gravity Processing — **D. Gillies/MSFC**

Containerless Processing Technology — **J. Rogers/MSFC**

Low-g versus Earth-g: Some Surprises — **R. German/Penn State**